THICK ICE DEPOSITS IN DEUTERONILUS MENSAE, MARS: REGIONAL DISTRIBUTION FROM RADAR SOUNDING. J.J. Plaut[1], J.W. Holt[2], J. W. Head, III[3], Y. Gim[1], P. Choudhary[2], D. M. Baker[3], A. Kress[3], and the SHARAD Team. [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, plaut@jpl.nasa.gov, [2]University of Texas Institute for Geophysics, Jackson School of Geosciences, University of Texas, Austin, TX 78758, [3]Department of Geological Sciences, Brown University, Box 1846, Providence, RI 02912.

Introduction: A class of landforms typically found in the mid-latitudes of Mars, including "lobate debris aprons" (LDA) and "lineated valley fill" (LVF), had long been hypothesized to contain a substantial fraction of water ice [1-6]. Observations by the SHAllow RADar (SHARAD) on Mars Reconnaissance Orbiter (MRO) have confirmed that these features consist predominantly of water ice in at least two regions of Mars, Eastern Hellas and Deuteronilus Mensae [7,8]. This finding is consistent with a formation mechanism involving the retreat of formerly extensive ice sheets and cold-based glaciers, combined with development of a protective surficial lag of debris shed from nearby high topography and/or exposed by sublimation [9-11]. In this study, we report on the regional distribution of these thick (100s of m) ice deposits in the Deuteronilus Mensae area, based on a comprehensive mapping campaign by SHARAD on MRO.

Deuteronilus Mensae: Deuteronilus Mensae (40-51° N, 14-35° E), part of the dichotomy boundary "fretted terrain" [12] contains a high concentration of LDAs and LVF [2-3] that occur at the bases of scarps of mesas, knobs, craters and valley walls [13]. Relief of the adjacent scarps is generally 1-2 km, and most of the LDAs themselves have 300-800 m of relief relative to the surrounding valley floors. LDAs are typically ~10 km wide, measured perpendicular to the trend of the adjacent scarp, with a range of widths of 5-25 km [14]. Crater counting and cross-cutting relationships indicate that the surfaces of LDAs and LVF in this area are mid-to-late Amazonian in age, while the surrounding plains are Hesperian and most of the plateau surfaces are Noachian [13,15].

SHARAD observations: SHARAD is an orbital subsurface radar sounder on MRO operating at a center frequency of 20 MHz. Vertical resolution is 15 m (free space), with a horizontal footprint of 0.3-1 km by 3-6 km. As of December, 2009, SHARAD has obtained over 250 observations of the Deuteronilus Mensae area (Figure 1). SHARAD normally operates on the nightside of the MRO orbit, collecting data with groundtracks trending from north-northeast to south-southwest. Most observations to date were collected with this geometry, although some dayside tracks are also shown in Figure 1. The mapping campaign has resulted in generally dense coverage, with only a few gaps between adjacent tracks larger than 20 km. For all the SHARAD observations, simulated radargrams depicting the position and expected intensity of echoes from off-nadir surface topography ("clutter") were generated and compared with the original SHARAD radargrams. In addition, potential subsurface returns were converted from a time-delay to a depth geometry assuming a wave propagation speed in ice, to evaluate the relationship of the detected interfaces with surrounding exposed topography [e.g., 7,8]. Finally, adjacent or overlapping tracks were examined where available to check for consistency of the subsurface detections. Detections indicated in Figure 1 were considered robust and worthy of mapping if they occurred in areas free of clutter, displayed the expected depth geometry and were seen in multiple tracks where possible.

Discussion: Mapping of subsurface interfaces indicates that thick masses of ice are quite common in the Deuteronilus Mensae area (Figure 1). Detections are widespread, at the bases of mesas and massifs, along linear and curvilinear dichotomy boundary scarps, and confined within valleys (LVF) or in some cases within impact craters. In many areas, the detection rate was 100%; i.e., where the morphology suggested the presence of LDA or LVF and the geometry was favorable for the observation, the reflector was indeed detected. For example, nearly every observation of the inner scarps of the quasi-circular (remnant impact crater?) features at 40N18E and 39N23E showed an unambiguous basal reflector. Similarly, in the area of numerous mesas and knobs around 44N25E, almost all of the observations showed reflections at the expected locations. While numerous detections were seen in the LVF, the detection rate was sometimes lower than on the classic LDAs. For example, the filled valley near 41N35E showed a reflector estimated at >1 km depth in one area, but did not show a reflector in other parts of the same valley. Some regional trends in detection rate are observed. At the northern edge of the study area, where the knobs and mesas show less relief, some of the LDAs did not show the expected reflectors. A clear decrease in detection rate is seen in the eastern part of the area, where some large, classic LDA features show little or no subsurface signature. Likewise, detections in LVF seem to decrease toward the southeast. The decrease in detections could be caused by one or a combination of several factors: increased signal attenuation due to composition or internal struc-

ture; a thicker surface lag; roughness at the surface or the basal interface. The latter effect may be present near 42N23E, where LDAs that developed on a rough impact ejecta blanket do not show subsurface detections, while the adjacent LDAs do. One interesting effect is observed in areas of highly transparent LDAs or LVF: subsurface detections can appear in radargrams from off-nadir buried interfaces. These reflectors are not predicted in the clutter simulations, nor are they in the expected position relative to the nadir track. While these are among the very few cases where SHARAD is sensitive "buried clutter," it is worth checking for this effect in other study areas. The implications of the widespread presence of thick masses of ice in the mid-latitudes of Mars are of course significant. This ice likely contains a record of climatic and other environmental conditions at the time of its deposition and flow. This may include evidence of habitability. The LDA and LVF deposits are a significant fraction of the known non-polar ice inventory on Mars, and they are intriguing targets for in situ exploration.

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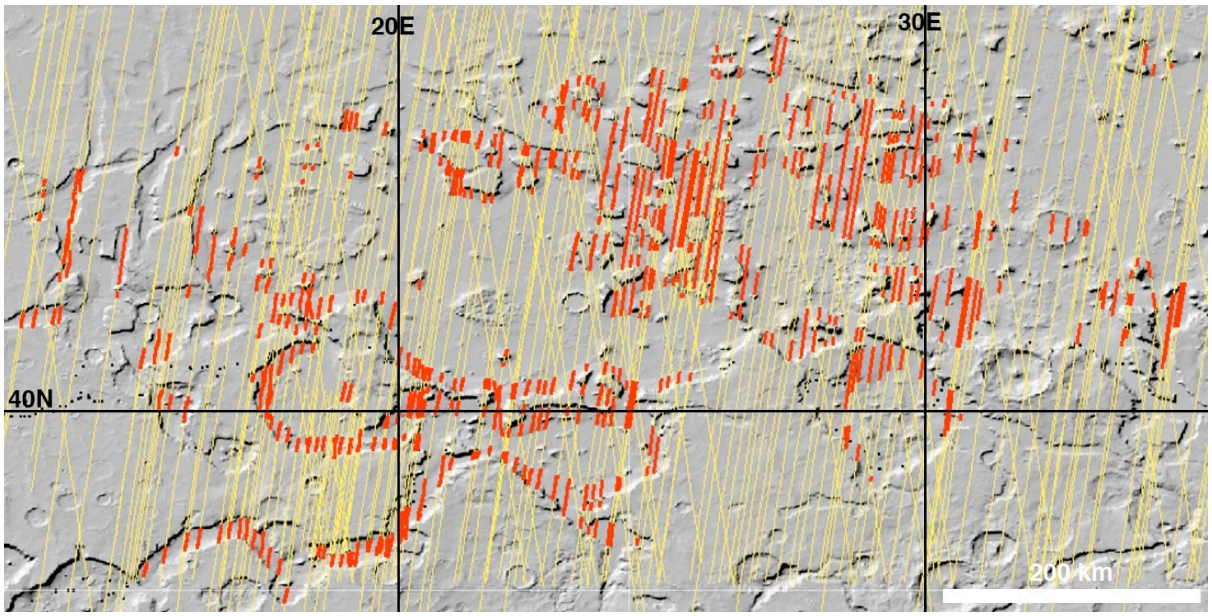

Figure 1. MOLA shaded relief map of the Deuteronilus Mensae area, with the groundtracks of SHARAD observations shown as yellow lines. The red segments indicate positions of robust subsurface detections below LDA or LVF deposits.